Sector Specific Technology Transfer Guide

Miscellaneous Chemical Industry

(SIC Groups 285, Paints and Allied Products, and 289, Miscellaneous Chemical Products)

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This guide was developed to provide an overview of pollution prevention practices and technologies available to the miscellaneous chemical industry. The pollution prevention strategies identified in this guide focus primarily on the reduction of air emissions. The guide has been organized by production processes and the pollution prevention strategies, and categorized by the initial costs of those technologies. Each technology is ranked according to the potential reductions in air emissions resulting from the implementation of those technologies (☼ = a low potential for significant emission reductions, ☼☼☼ = the highest potential for significant emission reductions).

Materials Management

Low Cost Pollution Prevention Technologies:

- **Schedule production to increase efficiency (☼☼) –** Schedule production to minimize product line change over to reduce equipment cleaning operations.
- **Running inventory (☼) –** Keep a running inventory of raw materials to avoid exceeding shelf life and generating off-spec materials, resulting in additional equipment cleaning operations.
- **First-in, first-out (☼) -** Use older materials first to avoid exceeding shelf life and generating off-spec materials, resulting in addition equipment cleaning operations.
- **Keep all containers used to store solvent-based reactants/cleaners and waste materials closed (☼)** – To reduce air emissions and preserve the chemical properties of the reactants and cleaners, instruct all employees to keep containers used to store these materials closed when not in use.

Medium Cost Pollution Prevention Technologies:

- **Reroute traffic in storage areas to reduce potential for damage (☼) -** Reroute heavy traffic from storage areas to minimize damage to raw, intermediate or final product storage containers. Damage to these containers could result in the loss of product, generate air emissions, and/or require the use of solvent for clean-up operations.

Milling (Grinding and Mixing)

Low Cost Pollution Prevention Technologies:

- **Reduce intermediate storage (☼☼)** - Take steps to reduce the need for intermediate storage, and subsequent equipment cleaning operations.

Medium Cost Pollution Prevention Technologies:

- **Purchase solid materials in slurry or paste form to reduce byproducts (☼☼) –** Milling a slurry or paste generates less particulate emissions than a dry solid.

High Cost Pollution Prevention Technologies:

- **Switch batch processes to continuous (☼☼☼) -** Use a continuous rather than a batch mill (and reactor) to increase efficiency and reduce equipment cleaning operations.
- **Pre-mix in-line mixers (☼☼) –** Pre-mix reactants and catalysts using in-line mixers to increase mixing efficiency and reduce air emissions.

Chemical Reaction

Low Cost Pollution Prevention Technologies:

- **Operator training (☼☼) –** Conduct hands-on training sessions for employees on proper operating procedures.
- **Inspect equipment (☼) –** Inspect equipment for leaks or malfunctions.
- **Monitoring of production defects (☼) –** Track the number of off-spec products, the type of variance, and the reactor or production line generating the variance. Use this information to determine the source and take corrective actions to reduce or eliminate future variances.

Medium Cost Pollution Prevention Technologies:

- **Use higher purity materials (☼☼☼) –** Use higher purity materials and catalysts to increase production efficiency and reduce the possibility of generating off-spec materials.
- **Reduce side reactions with inhibitors (☼☼☼) –** Use chemical inhibitors to inhibit side reactions that compete with the primary reaction and increase air emissions.
- **Avoid extreme operating conditions (☼☼) -** Keep temperature and pressure as close to ambient as possible to reduce byproducts and additional air emissions.

High Cost Pollution Prevention Technologies:

- **Redesign reactor (☼☼☼) -** Redesign reactor to increase catalyst effectiveness
- **Supercritical carbon dioxide (☼☼☼) -** Replace organic solvents with supercritical carbon dioxide (CO_2).
- **Flow distributor (☼☼) -** Install flow distributor at the reactor entrance to increase production.
- **Position air exchange fan/stack (☼☼) -** Position work place air exchange fan/stack placement so that air evaporation does not disturb the mixing tank head space.
- **Pre-filter reaction air (☼☼) -** Pre-filter reaction air (or use pure oxygen) to decrease byproducts due to impurities.

Separation (Filtration, Distillation, Reverse Osmosis, etc.)

Low Cost Pollution Prevention Technologies:

- **Separation steps modifications (☼☼)**
  - Remove corrosive and unstable materials from the reaction chamber as soon as possible.
  - Remove containment of highest-volume first.

- Perform the most difficult separation process last.

Medium Cost Pollution Prevention Technologies:

- **Separation steps modifications (☼☼)**
  - Perform high-purity recovery fraction separations last.
  - Use a procedure that results in the fewest number of by-products or intermediates.
- **Process simplification (☼☼)**
  - Avoid adding new components to the separation sequence.
  - If a mass separating agent is used, recover it in the subsequent separation step.
  - Do not use a second mass recovery agent to recover the first recovery agent.

High Cost Pollution Prevention Technologies:

- **Hybrid separative reactor (☼☼☼) -** Combine the chemical reactor with the separator in a hybrid, separative reactor, increasing yield and reducing byproducts and air emissions through better control of reactant addition and product removal.
- **Molecular sieve adsorbents (☼☼) -** Distillation of azeotrophic compounds, such as benzene and cyclohexane can be eliminated by contacting other azeotrophs, such as ethanol/water or isopropanol/water with molecular sieve adsorbents.

<u>Equipment Cleaning</u>

Low Cost Pollution Prevention Technologies:

- **Schedule cleaning right after use (☼☼)** - Clean tanks, containers, and equipment promptly after use to reduce need for additional or more aggressive cleaning solvents on dried materials.
- **Batch sequencing (☼☼) -** Sequence batches from light-to-dark to reduce cleaning needs.

Medium Cost Pollution Prevention Technologies:

- **Low HAP/VOC cleaning solvents (☼☼☼) -** Purchase non or low HAP/VOC solvents to reduce air emissions during cleaning.
- **Avoid on-site cleaning (☼☼) –** Avoid or minimize the need for on-site cleaning by purchasing reactants in lined drums or in large containers that can be returned to the supplier.
- **Increase cleaning efficiency (☼☼) -** Reduce amount of cleaning solvent used by use of more efficient nozzles and/or high pressure spray cleaning.
- **Use countercurrent rinsing sequencing (☼☼) -** Recycled dirty solvent is used to initially clean the tank or equipment. Following this step, recycled clean solution is used to rinse the dirty solution from the tank or equipment. Since the level of contamination builds up more slowly in the recycled clean solution than with a simple reuse solvent, solvent life is increased.

High Cost Pollution Prevention Technologies:

- **Replace solvent with mechanical cleaning (☼☼☼) -** Use mechanical cleaning methods such as rubber wipers in reaction chambers or plastic or foam "pigs" in pipes to replace or minimize solvent cleaning.

- **Dedicated (separated) lines (☼☼)** - Use dedicated mills, reactors, and separation units to reduce the frequency of cleaning due to product changes.

- **Use Teflon-lined tanks (☼☼) -** Use Teflon-lined tanks to reduce adhesion and improve drainage. The reduced amount of clingage will make dry cleaning more attractive.

Links to Additional Information

All Areas

- Sector Notebook: Organic Chemical Industry. www.epa.gov
- Guides to Pollution Prevention: The Paint Manufacturing Industry. www.epa.gov
- Coatings Alternative Guide (CAGE). http://cage.rti.org
- Design for the Environment Program, US EPA. www.epa.gov
- Green Chemistry Expert System. US EPA. www.epa.gov/oppt/greenchemistry
- Green Engineering Textbook. US EPA. www.epa.gov/oppt/greenengineering
- ISSDS Integrated Solvent Substitution Data System. http://es.epa.gov/issds
- SAGE Solvent Alternative Guide. http://es.epa.gov/ssds/ssds.html

Additional Sites

- Pollution Prevention Resource Exchange: www.p2rx.org/
- Indiana Clean Manufacturing Technology and Safe Materials Institute: www.purdue.edu/cmti
- IDEM's Office of Pollution Prevention & Technical Assistance: www.in.gov/idem/oppta

Summary Table

	Good Pollution Reduction Opportunities →		Best Pollution Reduction Opportunities
Lowest Cost	• Running inventory of raw materials ***(MM)*** • First-in, first out ***(MM)*** • Keep containers closed ***(MM)*** • Inspect Equipment ***(CR)*** • Monitor production defects: ***(CR)***	• Schedule production ***(MM)*** • Reduce intermediate storage ***(M)*** • Operator training ***(CR)*** • Remove corrosives & unstable products first ***(S)*** • Separate high volume component first ***(S)*** • Difficult separations last ***(S)*** • Clean right after use ***(EC)*** • Sequence light to dark ***(EC)***	
	• Reroute traffic in storage areas ***(MM)***	• Use slurries in place of solids ***(M)*** • Avoid extreme operating conditions ***(CR)*** • No new components to separate ***(S)*** • Recover separation agent in next step ***(S)*** • Don't use second mass separation agent to recover the first one ***(S)*** • Sequence separation steps to minimize byproducts ***(S)*** • Perform high-purity recovery fraction separations last ***(S)*** • Avoid on-site cleaning ***(EC)*** • Use more efficient cleaning application tools ***(EC)*** • Countercurrent rinsing ***(EC)***	• Higher purity materials ***(CR)*** • Chemical inhibitors ***(CR)*** • Low HAP/VOC solvents ***(EC)***
Highest Cost		• Pre-mix, in-line mixers ***(M)*** • Flow distributor ***(CR)*** • Position air exchange ***(CR)*** • Pre-filter reaction air ***(CR)*** • Molecular sieve adsorbents ***(S)*** • Teflon-lined tanks ***(EC)*** • Dedicated lines ***(EC)***	• Switch batch processes to continuous ***(M)*** • Redesign reactor ***(CR)*** • Supercritical CO_2 ***(CR)*** • Hybrid separative reactor ***(S)*** • Mechanical cleaning ***(EC)***

MM – Materials Management ***CR*** – Chemical Reaction ***EC*** – Equipment Cleaning
M – Milling ***S*** – Separation